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VARIABLE SHOCK-FREE TIMES WITH INFORMATIVE AND UNINFORMATIVE STIMULI

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Three rats were trained on a fixed-ratio escape procedure in which responding produced one of two equiprobable outcomes—a 10-second or 60-second shock-free period. Before the fixed-ratio requirement was satisfied, brief shocks were presented at irregular intervals averaging either 15 or 30 seconds. Two conditions, differing in the relationship between exteroceptive stimuli and the outcomes, were studied. In the uninformative (uncorrelated) condition, the same stimulus was presented during both outcomes. In the informative (correlated) condition, one stimulus was present during the 10-second outcome only; another stimulus was present during the 60-second outcome only. Subjects pressed faster in the uninformative condition than they did in the informative condition. The inadequacy of the information hypothesis in accounting for the findings is discussed, and an alternative hypothesis is offered.

Key words: conditioned reinforcement, negative reinforcement, escape, rats

The information hypothesis of conditioned reinforcement (Hendry, 1969) states that uncertainty is an aversive or undesirable condition and a neutral stimulus that reduces uncertainty (*i.e.*, is informative) should be reinforcing. Findings from several studies (Hendry, 1969; Lieberman, 1972; Schaub, 1969; Schaub and Honig, 1969; Wilton and Clements, 1971) support the information hypothesis.

In Wilton and Clements' study, a pigeon's first key peck after 15 sec (fixed interval 15-sec) produced one of two stimuli. Each stimulus occurred with a probability equal to 0.5. Approximately 35 sec after the onset of a stimulus, one of two outcomes—food reinforcement or nonreinforcement—occurred. Each outcome also occurred with a probability equal to 0.5. In the informative (correlated) condition, one stimulus was presented exclusively during the reinforcement outcome; a different stimulus was presented exclusively during the nonreinforcement outcome. In the uninformative (uncorrelated) condition, each stimulus was presented equally often during both the reinforcement and nonreinforcement outcomes. When the fixed-interval response produced the informative stimuli, subjects responded faster than when responding produced the uninformative stimuli.

The present study attempted to provide an aversive-control analogue to Wilton and Clements' food-reinforcement study; the reinforcing value of informative *versus* uninformative stimuli were compared, with shock-free time, rather than food, as the primary reinforcing event. The present procedure is similar to an escape procedure reported by Azrin, Holz, and Hake (1963), and Dinsmoor (1962). In the Dinsmoor study, rats received intermittent brief shocks in the absence of a response. A response intermittently produced a shock-free period. Different stimuli were associated with the shock and shock-free periods. The length of the shock-free period was a parameter in the Dinsmoor and Azrin *et al.* studies, but neither of these studies focused on the present issue—the effects of two shock-free periods following a response, and the effect of associating different stimuli with these shock-free periods.

The present study, like Wilton and Clements', compared the reinforcing properties of an informative *versus* an uninformative condition. In the informative (correlated) condition, one stimulus was presented exclusively

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during one shock-free period, and a different stimulus was presented exclusively during the other shock-free period. In the uninformative (uncorrelated) condition, the same stimulus was present during both shock-free periods.

The present study was primarily concerned with determining which of the two conditions, uninformative or informative, would result in the higher rate of bar pressing.

METHOD

Subjects

Three experimentally naive female albino rats (Holtzman Co.), approximately 90 to 100 days old at the start of the experiment, were housed in individual cages and maintained on free food and water throughout the experiment.

Apparatus

The experimental chamber was a modified rat box in a sound-attenuating shell. A window and one-way mirror in the sound-attenuating shell allowed unobtrusive observation of the subject. The chamber, 23.3 cm long, 20.4 cm wide, and 20 cm high, was modified so that the bars in the grid floor were parallel with the 23.3-cm wall. To reduce unauthorized escape, an inner, clear plastic ceiling was mounted 11.5 cm above the grid floor. A Gerbrands rat lever required approximately 0.196 N to depress and was mounted 7.1 cm from the side along the 20.4-cm wall, 6.3 cm above the grid floor. Cue lights (24 V) were mounted 2.5 cm on either side of the response lever. A tone was provided by a Mallory Sonalert (1000 Hz, 80 dB).

A constant-current shock source (BRS Inc.—SGS003, 10% duty cycle) delivered 3.0 mA shock for 0.3 sec to grids, front and rear walls, and rat lever. Stainless-steel grid bars were 0.15 cm in diameter, spaced 1.3 cm apart center-to-center. Solid-state switching circuits housed in an adjacent room controlled all experimental events. Houselights (24 V) and masking noise (80 dB) operated throughout the session.

Procedure

The conditioning procedure consisted of three parts: (1) pairing of stimuli with shock and shock-free periods; (2) preliminary escape training; (3) uncorrelated *versus* correlated conditions. In all three parts of the experiment, shock delivery was controlled by a 20-interval film tape produced according to Fleshler and Hoffman (1962) tables. The film programmer operated continuously throughout the session. The onset and offset of the houselights and masking noise indicated the beginning and end, respectively, of sessions.

Pairing of stimuli with shock and shock-free periods. The initial sessions were for the purpose of associating the two stimulus complexes with the presence or absence of shock. This is comparable to magazine training in positive reinforcement experiments. On the first day of pairings, the session began with a 5-min shock period in which shocks were delivered at irregular intervals averaging 10 sec (VT 10-sec). This period was followed by a 5-min shock-free period. A stimulus complex of continuously-operating Sonalert and continuously-illuminated cue lights was presented during the shock-free periods. Shock and shock-free periods alternated throughout the 1-hr session. The houselights were on during the entire session. On the second and third day, the shock schedule was changed to VT 15-sec and VT 30-sec, respectively. Shock and shock-free periods were both 5 min. Only during these sessions was session duration 1 hr in length; thereafter, sessions were 3 hr long and were separated by a 21-hr period.

Preliminary escape training. On the fourth day, fixed-ratio escape conditioning began. During preliminary escape training, shocks were always delivered on a VT 30-sec schedule. In the first session, one lever press (FR 1) produced one of two equiprobable outcomes—either a 10-sec or a 60-sec shock-free period. A stimulus complex, which consisted of both continuously-operating Sonalert and cue lights, was presented during both shock-free periods. As responding stabilized, the fixed-ratio requirement was increased. Subject OR 50 received one session at FR 1, and one session at FR 2; Subject OR 100 received two sessions at FR 1, one session at FR 2, and five sessions at FR 3; Subject OR 24 received three sessions at FR 1, one session at FR 3, and five sessions at FR 4.

During preliminary training with FR 3 and VT 30-sec shock schedule, one subject (OR 100) responded at low rates (0.5 responses per minute), and another subject (OR 24) with a FR 4 requirement stopped responding. Therefore, for Subject OR 100 and Subject OR 24,

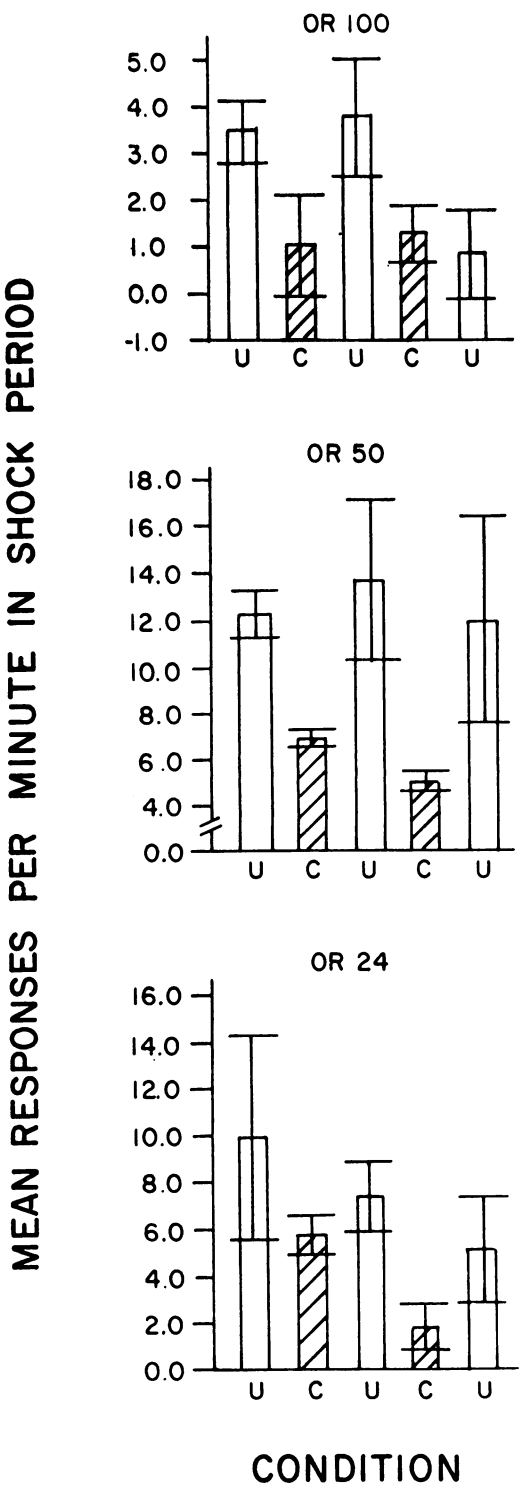

Fig. 1. Mean response rate in shock period for each subject based on last four sessions in the uncorrelated (U) and correlated conditions (C). The uncorrelated (U) and correlated (C) conditions refer to the uninformative and informative conditions, respectively. Standard Deviation of last four sessions for each condition is indicated.

the response requirement and shock schedule was changed to FR 2 and VT 15-sec, and remained at these values for the rest of the experiment. Subject OR 50 received shock on a VT 30-sec schedule with a response requirement of FR 4 throughout the remainder of the experiment.

Uncorrelated versus *correlated condition,* Following preliminary training, all subjects were placed in the uncorrelated (uninformative) condition. In the uncorrelated condition, as in preliminary training, satisfying the fixed-ratio response requirement produced one of two outcomes—either a 60-sec or 10-sec shock-free period. Each outcome followed the successful completion of the FR with a probability equal to 0.5. The stimulus complex associated with both the 60-sec and 10-sec shock-free periods consisted of a continuously-operating Sonalert and continuously-illuminated cue lights.

In the correlated (informative) condition, completing the FR requirement also produced one of two equiprobable outcomes—either a 60- or 10-sec shock-free period. The 60-sec shock-free period, however, was exclusively associated with a stimulus complex consisting of both cue light and Sonalert operating in a 1.0-sec on, 1.0-sec off cycle. The 10-sec shock-free period was associated with only a clicker.

All subjects received the correlated and uncorrelated conditions in the following order: uncorrelated, correlated, uncorrelated, correlated, uncorrelated. Each of the three subjects received the following number of sessions, respectively in each condition: Subject OR 50—26, 14, 7, 7, 6; Subject OR 24—24, 15, 14, 7, 8; Subject OR 100—20, 8, 7, 11, 7.

RESULTS AND DISCUSSION

Figure 1 shows for each subject the mean fixed-ratio response rates (responses per minute during shock period) averaged across the last four sessions under the uncorrelated and correlated conditions. The order in which the correlated and uncorrelated conditions were administered is shown along the abscissa from left to right. Mean response rates were lower in the correlated (informative) condition than in the

uncorrelated (uninformative) condition. The only exception is the last data point (uncorrelated condition) for Subject OR 100. Failure to recover the relatively high response rate in the last uncorrelated condition may have been due to the emergence of an unauthorized escape response. The rat (OR 100) was periodically, but unsystematically, observed throughout the experiment, and only in the last uncorrelated condition was unauthorized escape responding noted.

The information hypothesis makes predictions concerning the outcome of the present study that are opposite to the observed results. The information hypothesis (Hendry, 1969) states that uncertainty is an undesirable state, and that the reinforcing value of a stimulus is a direct function of the amount of uncertainty that is reduced. In the correlated (informative) condition, one of two stimuli indicated which of the two shock-free periods was in effect. According to the information hypothesis, this more "informative" condition should have greater reinforcing properties than the uncorrelated condition, because it reduced uncertainty with respect to which of the two possible shock-free periods was in effect. The *less* informative condition, however, was found to have greater reinforcing properties than the correlated condition.

Evidence inconsistent with information theory has come from two types of observing-response study. In the first type, the stimulus correlated with the higher-valued component has been shown to be solely responsible for maintenance of the observing response (Auge, 1974; Kendall and Gibson, 1965; Mulvaney, Dinsmoor, Jwaideh, and Hughes, 1974). According to information theory, production of either correlated stimulus, regardless of the value of primary reinforcing events with which it is correlated, should maintain the observing response. In the second type of observing-response study (Kendall, 1973; McMillan, 1974; Steiner, 1970) the probability of the higher-valued component was manipulated. Results have shown that the informative stimuli have their greatest reinforcing value when the probability of the higher-valued component is about 0.35. According to information theory (Hendry, 1969), the reinforcing value of the informative stimuli should be optimal when the two components (high- and low-valued) each occur with a probability equal to 0.5.

The present study found higher responding to produce the uninformative (uncorrelated) stimuli, whereas Wilton and Clements (1971) found higher responding to produce the informative (correlated) stimuli. This qualitative difference when shock-free time rather than food is the primary reinforcer, may be due to two factors: (1) shock and food are probably inverse in their effects; and (2) a primary event immediately following a response has more influence on responding than an identical event following a response after a long delay.

In the case of food, there is a direct relationship between response rate and immediacy (Chung and Herrnstein, 1967). When shock follows responding, however, there is an inverse relationship between rate of responding and immediacy of the shock (Cohen, 1968). This is a restatement of the punishment gradient. In the present study, the two shock-free periods could be viewed as 10- and 60-sec delays to a situation containing shock. Thus, the 10-sec delay to the shock period may have had the opposite effect on responding, as compared to a short delay to food.

Another factor accounting for the difference between food and shock could be the disproportionately greater effect of short delays to primary events following responding. Killeen (1968) showed that food that occurs immediately following a response influences responding more than food further removed in time; the organism seems to use a nonlinear averaging process. If the effect of shock is, as Fantino (1973) suggested, equivalent to food, but opposite in direction, it might be expected that immediate shock would also be "weighted" more heavily than shock more removed in time.

The apparent discrepancy in the reinforcing properties of correlated and uncorrelated conditions when food *versus* shock is used, may be resolved if we abandon the information theory and adopt an alternative hypothesis: that the reinforcing value of correlated stimuli is determined by two factors—the delay to the primary events and the type of primary event, *i.e.*, positive (food) or negative (shock). If a stimulus is associated only with a short delay to shock and another stimulus is associated only with a long delay, responding may be suppressed due to the disproportionately suppressive influence of the short delay. If a short and long delay to food are arranged, however,

responding may be increased due to the disproportionately facilitative influence of the short delay.

Information theory has been unsupported in several positive reinforcement studies. The present data imply that the information theory is also incorrect with negative reinforcement.

REFERENCES

Auge, R. J. Context, observing behavior, and conditioned reinforcement. *Journal of the Experimental Analysis of Behavior,* 1974, **22,** 525-533.

Azrin, N. H., Holz, W. C., Hake, D. F., and Ayllon, T. Fixed-ratio escape reinforcement. *Journal of the Experimental Analysis of Behavior,* 1963, **6,** 449-456.

Chung, S. and Herrnstein, R. J. Choice and delay of reinforcement. *Journal of the Experimental Analysis of Behavior,* 1967, **10,** 67-74.

Cohen, P. S. Punishment: the interactive effects of delay and intensity of shock. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 789-799.

Dinsmoor, J. A. Variable-interval escape from stimuli accompanied by shocks. *Journal of the Experimental Analysis of Behavior,* 1962, **5,** 41-47.

Fantino, E. Aversive control. In J. A. Nevin and G. S. Reynolds (Eds), *The study of behavior.* Glenview, Illinois: Scott, Foreman, 1973. Pp. 239-274.

Fleshler, M. and Hoffman, H. S. A progression for generating variable-interval schedules. *Journal of the Experimental Analysis of Behavior,* 1962, **5,** 529-530.

Hendry, D. P. Introduction. In D. P. Hendry (Ed), *Conditioned reinforcement.* Homewood, Illinois: Dorsey Press, 1969. Pp. 1-35.

Kamin, L. J. The delay-of-punishment gradient. *Journal of Comparative and Physiological Psychology,* 1959, **52,** 434-437.

Kendall, S. B. Effects of two procedures for varying information responses. *Journal of the Experimental Analysis of Behavior,* 1973, **20,** 73-83.

Kendall, S. B. and Gibson, D. A. Effects of discriminative stimulus removal on observing behavior. *The Psychological Record,* 1965, **15,** 545-551.

Killeen, P. On the measurement of reinforcement frequency in the study of preference. *Journal of the Experimental Analysis of Behavior,* 1968, **11,** 263-269.

Lieberman, D. A. Secondary reinforcement and information as determinants of observing behavior in monkeys (*Macaca mulatta*). *Learning and Motivation,* 1972, **3,** 341-358.

McMillan, J. C. Average uncertainty as a determinant of observing behavior. *Journal of the Experimental Analysis of Behavior,* 1974, **22,** 401-408.

Mulvaney, D. E., Dinsmoor, J. A., Jwaideh, A. B., and Hughes, L. H. Punishment of observing by the negative discriminative stimulus. *Journal of the Experimental Analysis of Behavior,* 1974, **21,** 37-44.

Schaub, R. E. Response-cue contingency and cue effectiveness. In D. P. Hendry (Ed), *Conditioned reinforcement.* Homewood, Illinois: Dorsey Press, 1969. Pp. 342-356.

Schaub, R. E. and Honig, W. K. Reinforcement of behavior with cues correlated with extinction. *Psychonomic Science,* 1967, **1,** 15-16.

Steiner, J. Observing responses and uncertainty reduction: II. The effect of varying the probability of reinforcement. *Quarterly Journal of Experimental Psychology,* 1970, **22,** 592-599.

Wilton, R. N. and Clements, R. O. Observing responses and informative stimuli. *Journal of the Experimental Analysis of Behavior,* 1971, **15,** 199-204.

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